Analysis of arterial mechanics during head down tilt bed rest

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Cardiovascular Laboratory

SPACE LIFE SCIENCES SUMMER INSTITUTE

National Aeronautics and Space Administration

Introduction

- Hometown: Chattanooga, TN
- Career Goals:
  - Ph.D. in Biomedical Engineering, specializing in Tissue Engineering
  - Product oriented research in industry or government
- Why NASA? Mission and deliverables oriented
- Internship Objectives:
  - Data Analysis
  - Poster presentation at BMES Annual Meeting
  - Publication

Background

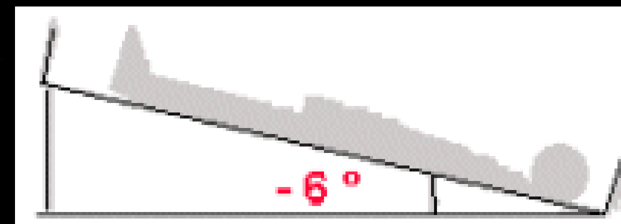
Cardiovascular Lab

- Investigate how weightlessness affects the cardiovascular system to aid in the improvement of astronaut health, develop countermeasures, and potentially benefit other populations on Earth
- Tests: head-down tilt bed rest (HDTBR), parabolic flight, hypovolemia models, and spaceflight

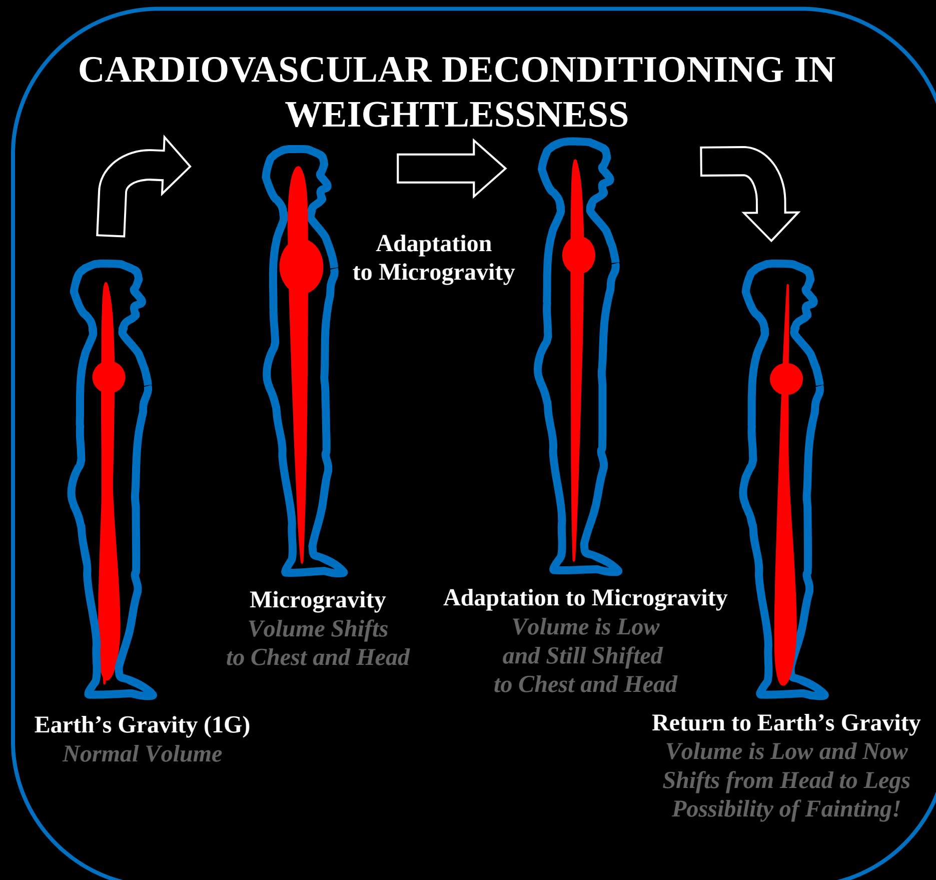
My Role

- Project 1: Define the frequency and pattern of mid-ventricular obstruction in the heart during high intensity exercise in a hypovolemic state
- Project 2: Analysis of arterial mechanics during HDTBR

Arterial Mechanics



- HDTBR
  - Physiological deconditioning similar to space
  - -6° head down
  - Ground based
  - Days analyzed: BR-5, BR60, BR+3

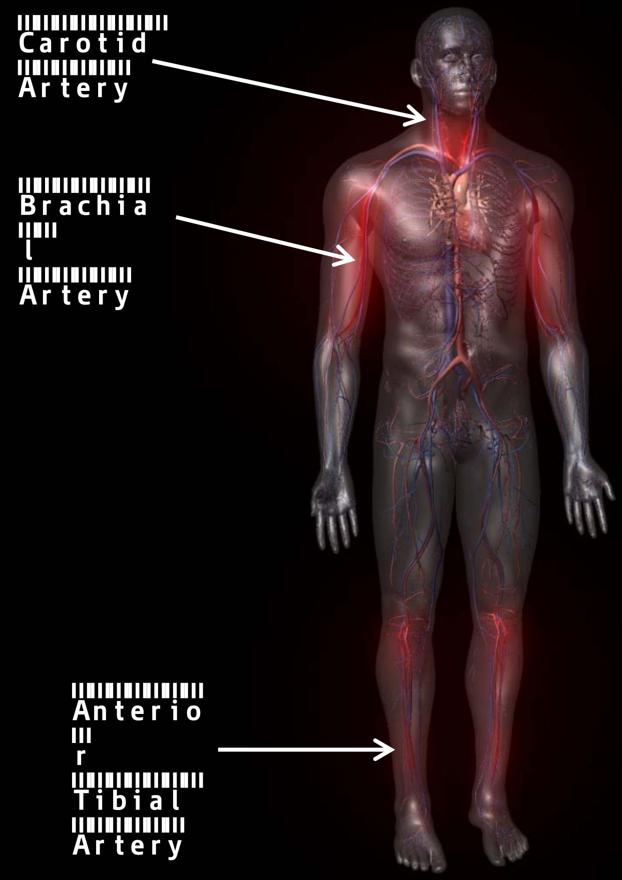


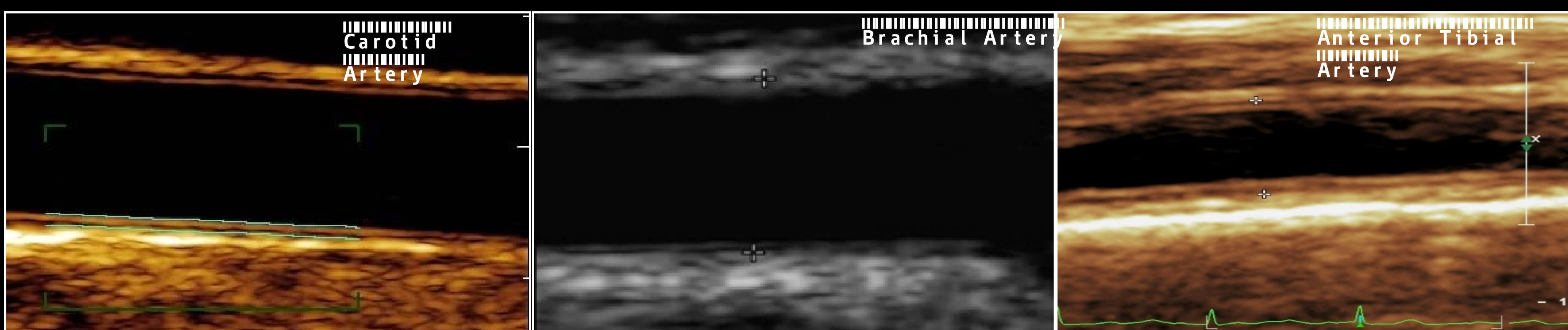
Arterial Mechanics

- 3 arteries analyzed

Carotid Artery – 13 subjects (7M, 6F, mean age 35±8, weight 71±10 kg, and height 168±9 cm)

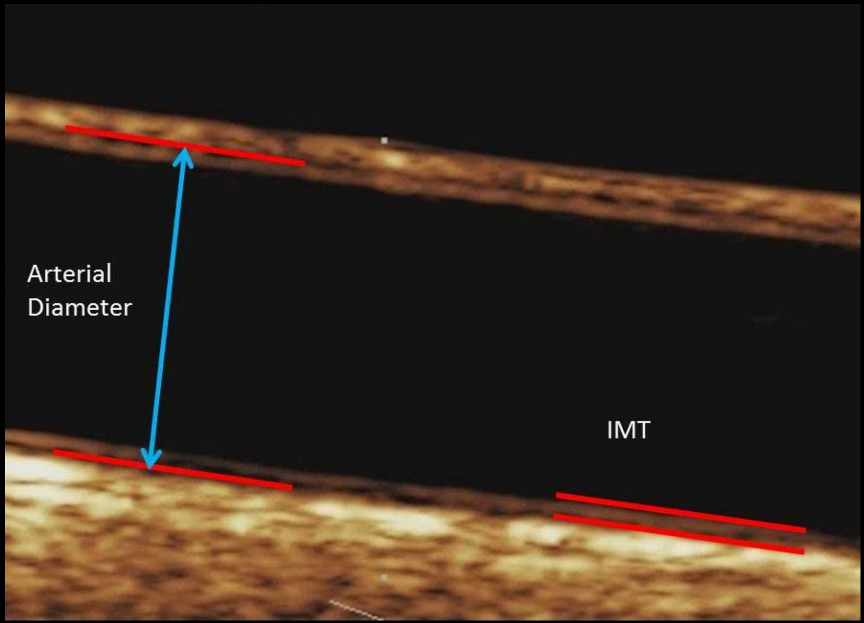
Brachial and Tibial Arteries – 11 different subjects (8M, 3F, mean age 34±9, weight 74±16 kg, and height 170±9 cm)





Arterial Mechanics Cont.

- Intima-Media Thickness (IMT)



- Mechanical Properties

Strain $\left[\frac{(SD-DD)}{DD}\right]$

Distensibility Coefficient (DC) $\left[\frac{2\,(SD-DD)}{PP\,*DD}\right]$

Stiffness (β) $\left[ln\left(\frac{SBP}{DBP}\right) * \frac{DD}{(SD-DD)}\right]$

Pressure-Strain Elastic Modulus (PSE) $\left[0.1333 * PP * \frac{DD}{(SD-DD)}\right]$

Arterial Mechanics Results

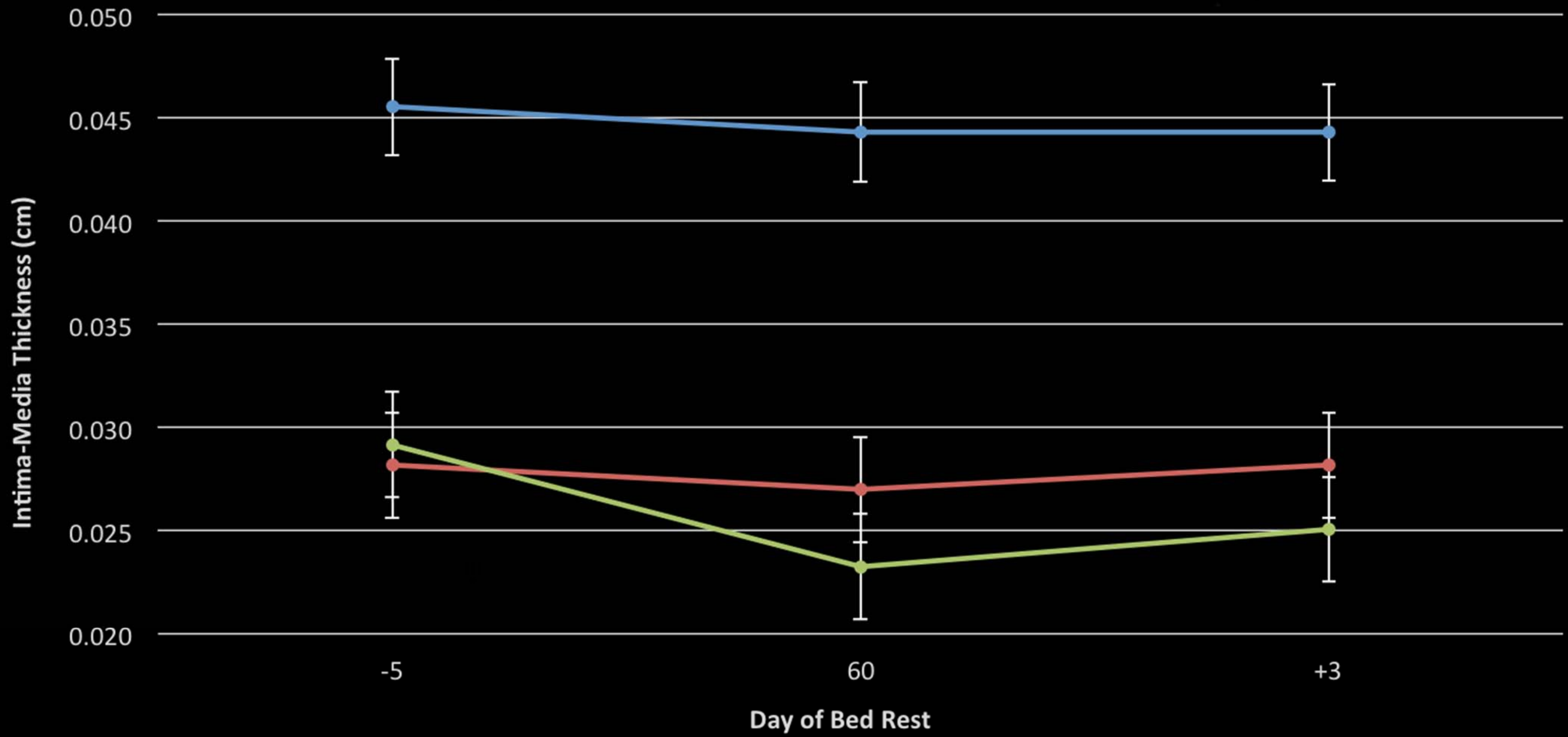
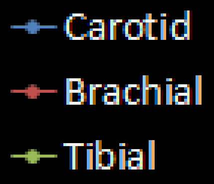


Figure 1. Carotid IMT margins were significantly thicker than the brachial and tibial IMT ($p < 0.001$). The tibial IMT decreased relative to the brachial response from BR -5 to BR 60 and BR+3 ($p < 0.05$). The tibial IMT was thinner on BR60 ($p < 0.001$) and did not recover by BR+3 ($p = 0.02$). Error bars represent 95% confidence intervals.

Arterial Mechanics Results Cont.



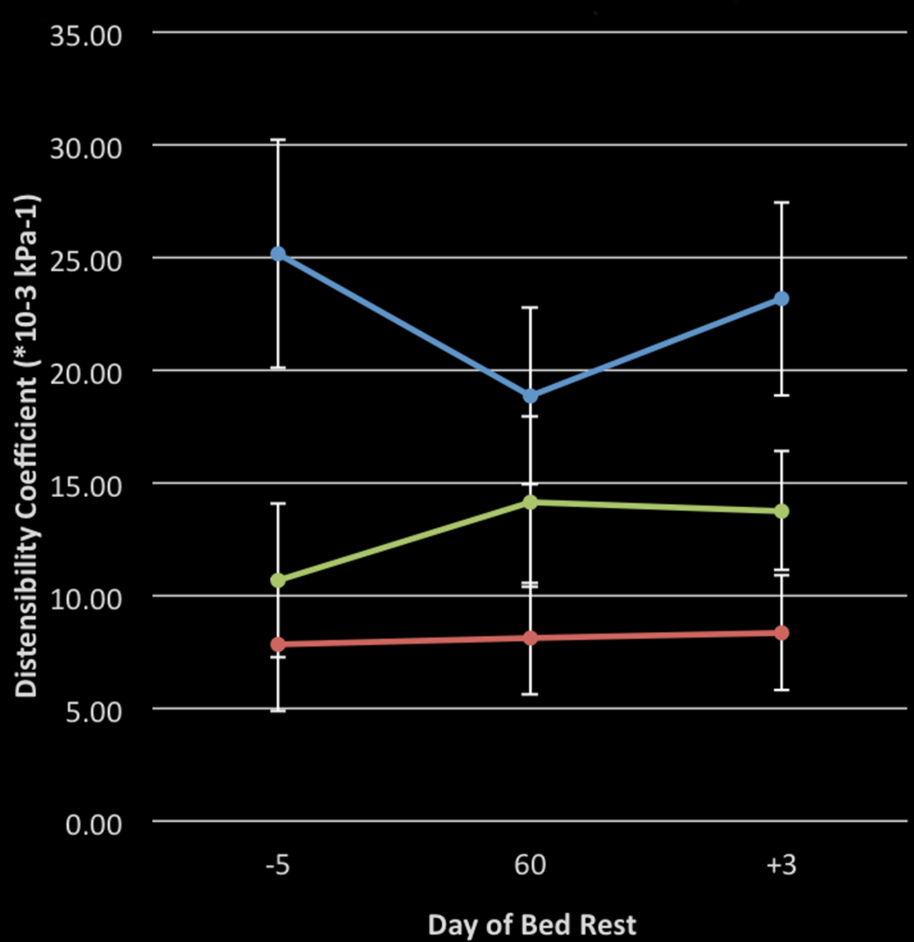


Figure 2. The tibial artery trended towards increased DC ($p = 0.1$) from BR-5 to BR+3. Error bars represent 95% confidence intervals.

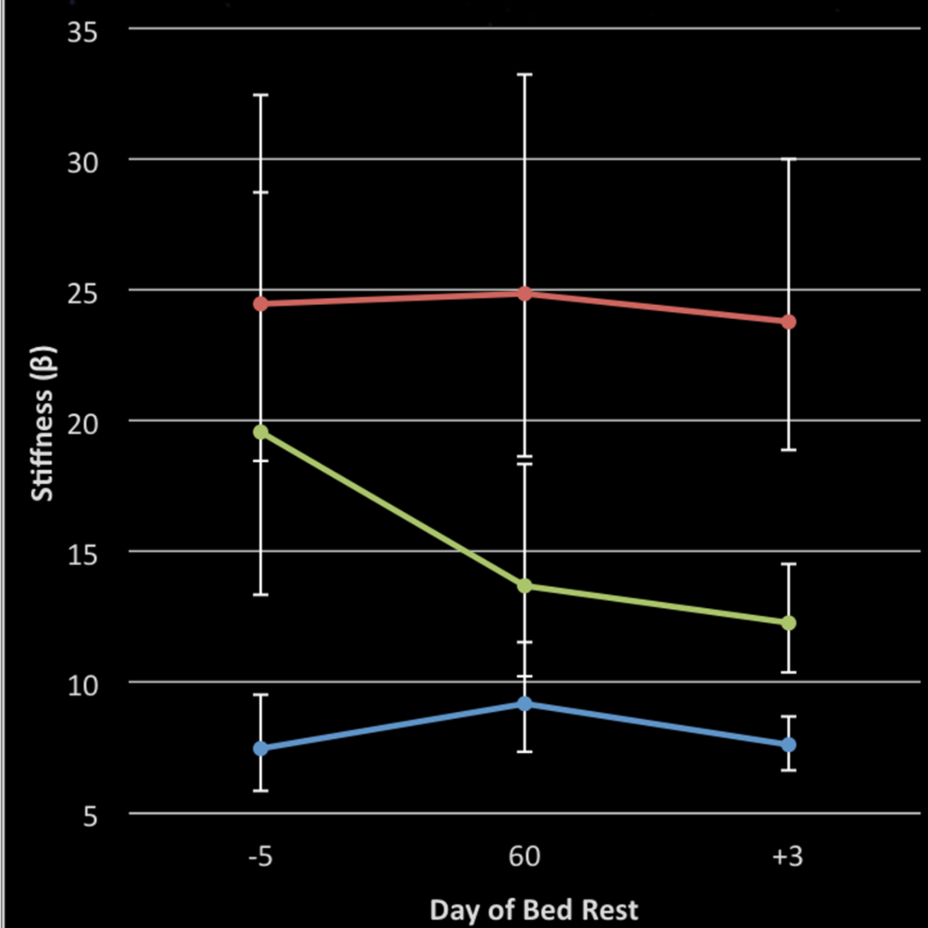


Figure 3. The tibial artery trended towards decreased stiffness ($p = 0.06$) from BR-5 to BR+3. Error bars represent 95% confidence intervals.

Arterial Mechanics Results Cont.

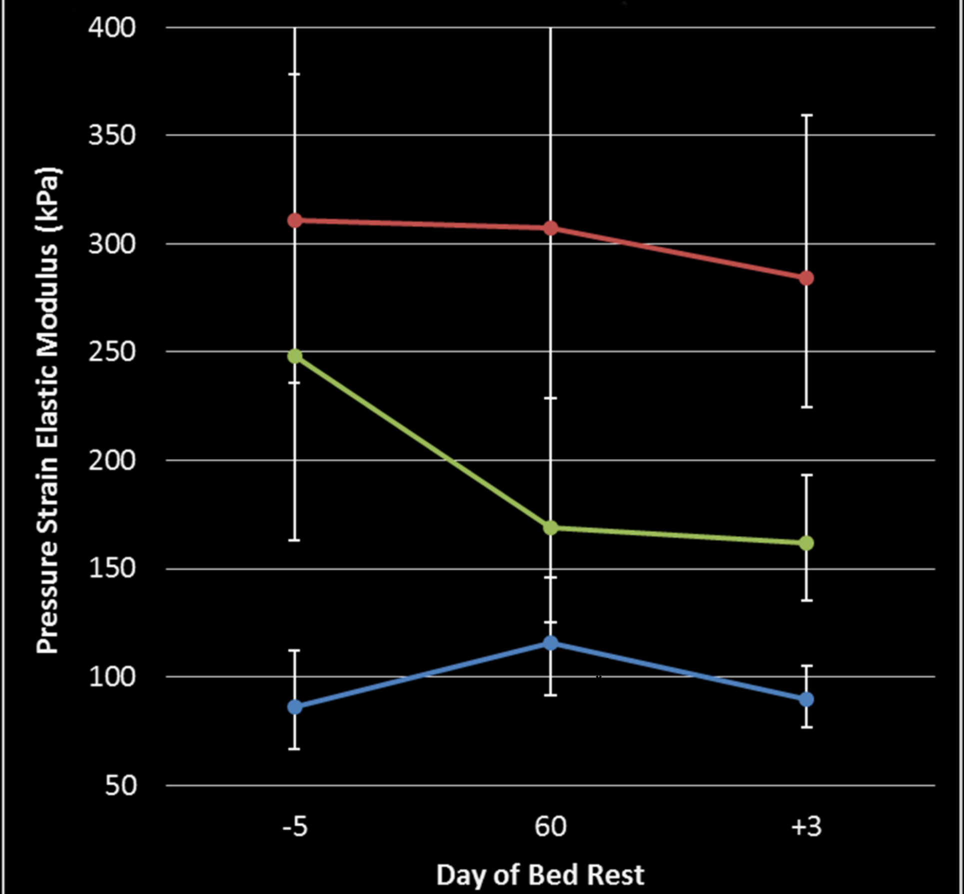


Figure 4. The tibial artery trended towards smaller moduli (p = 0.1) from BR-5 to BR+3. Error bars represent 95% confidence intervals.

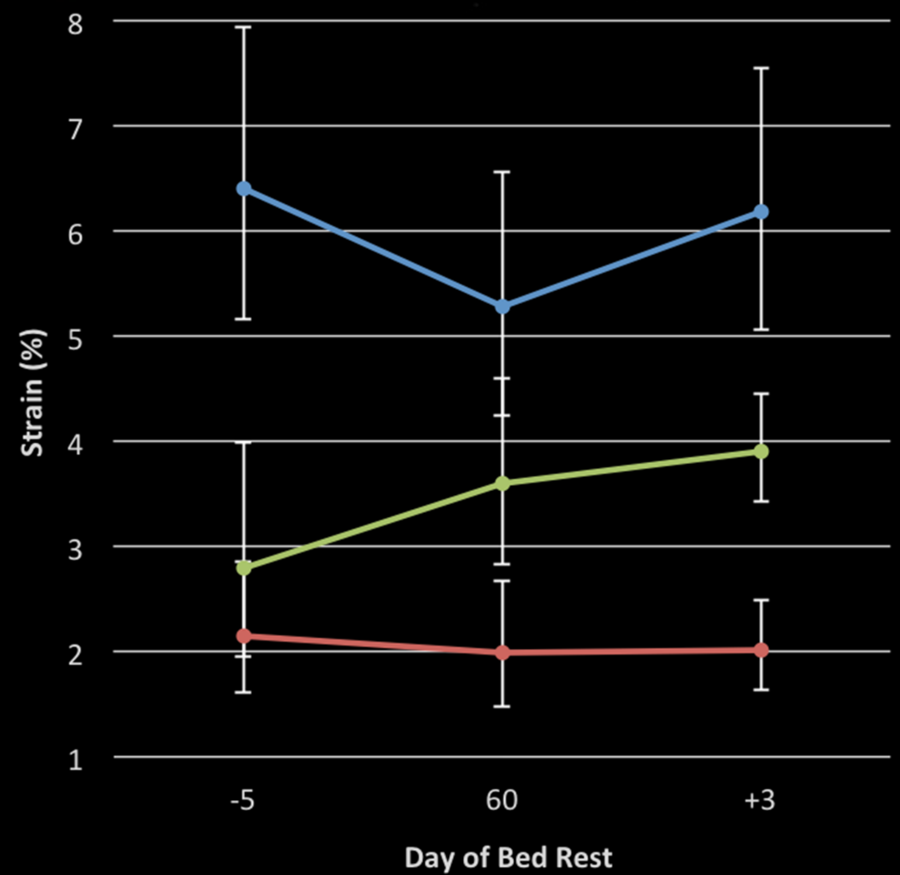


Figure 5. Strain margins are not significantly different between days of bed rest within vessels. Error bars represent 95% confidence intervals.

Arterial Mechanics Discussion

- Carotid, brachial, and tibial arteries react differently to HDTBR as a ground based analog of spaceflight.
- After slight variations during bed-rest, arterial mechanical properties and IMT return to pre-bed rest values. This does not appear to be true for the tibial stiffness and PSE, which continue to decrease post-bed rest while the DC increases.
- Limitations:
  - Small n value
  - Boundary determination methods
  - Small measurement differences
  - Single, non-blinded analysis

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Sources

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